JAVA - MULTITHREADING

Java provides built-in support for *multithreaded programming*. A multithreaded program contains two or more parts that can run concurrently. Each part of such a program is called a thread, and each thread defines a separate path of execution.

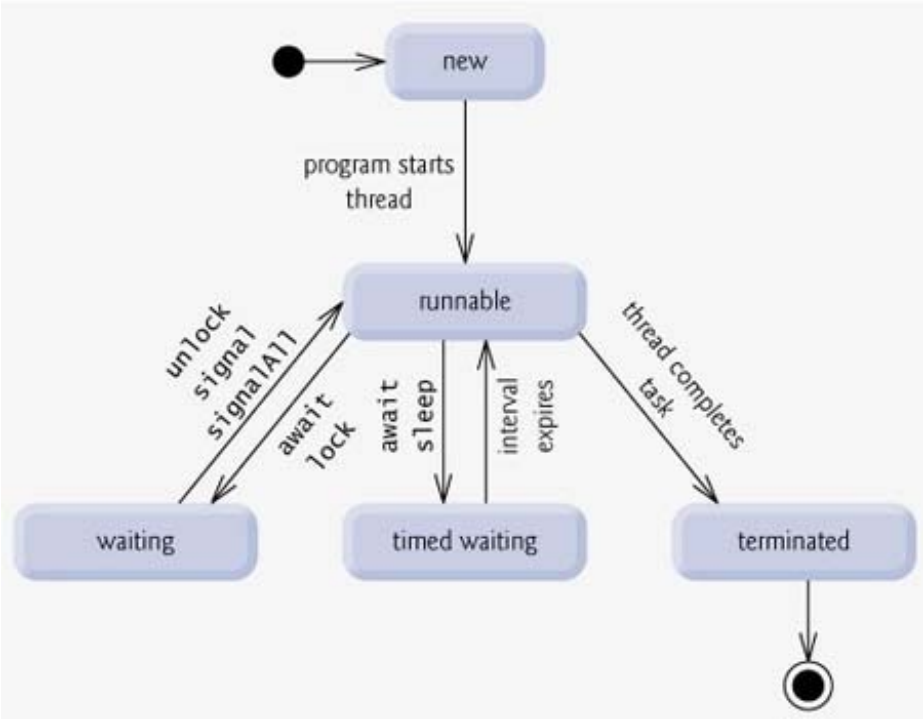
A multithreading is a specialized form of multitasking. Multitasking threads require less overhead than multitasking processes.

I need to define another term related to threads: **process:** A process consists of the memory space allocated by the operating system that can contain one or more threads. A thread cannot exist on its own; it must be a part of a process. A process remains running until all of the non-daemon threads are done executing.

Multithreading enables you to write very efficient programs that make maximum use of the CPU, because idle time can be kept to a minimum.

Life Cycle of a Thread:

A thread goes through various stages in its life cycle. For example, a thread is born, started, runs, and then dies. Following diagram shows complete life cycle of a thread.



Above mentioned stages are explained here:

- **New:** A new thread begins its life cycle in the new state. It remains in this state until the program starts the thread. It is also referred to as a born thread.
- **Runnable:** After a newly born thread is started, the thread becomes runnable. A thread in this state is considered to be executing its task.
- **Waiting:** Sometimes a thread transitions to the waiting state while the thread waits for another thread to perform a task.A thread transitions back to the runnable state only when another thread signals the waiting thread to

continue executing.

- **Timed waiting:** A runnable thread can enter the timed waiting state for a specified interval of time. A thread in this state transitions back to the runnable state when that time interval expires or when the event it is waiting for occurs.
- **Terminated:** A runnable thread enters the terminated state when it completes its task or otherwise terminates.

Thread Priorities:

Every Java thread has a priority that helps the operating system determine the order in which threads are scheduled.

Java priorities are in the range between MIN_PRIORITY (a constant of 1) and MAX_PRIORITY (a constant of 10). By default, every thread is given priority NORM_PRIORITY (a constant of 5).

Threads with higher priority are more important to a program and should be allocated processor time before lower-priority threads. However, thread priorities cannot guarantee the order in which threads execute and very much platform dependentant.

Creating a Thread:

Java defines two ways in which this can be accomplished:

- You can implement the Runnable interface.
- You can extend the Thread class, itself.

Create Thread by Implementing Runnable:

The easiest way to create a thread is to create a class that implements the **Runnable** interface.

To implement Runnable, a class need only implement a single method called **run( )**, which is declared like this:

```
public void run( )
```

You will define the code that constitutes the new thread inside run() method. It is important to understand that run() can call other methods, use other classes, and declare variables, just like the main thread can.

After you create a class that implements Runnable, you will instantiate an object of type Thread from within that class. Thread defines several constructors. The one that we will use is shown here:

```
Thread(Runnable threadOb, String threadName);
```

Here *threadOb* is an instance of a class that implements the Runnable interface and the name of the new thread is specified by *threadName*.

After the new thread is created, it will not start running until you call its **start( )** method, which is declared within Thread. The start( ) method is shown here:

```
void start( );
```

Example:

Here is an example that creates a new thread and starts it running:

```
// Create a new thread.
class NewThread implements Runnable {
```

```
   Thread t;
   NewThread() {
      // Create a new, second thread
      t = new Thread(this, "Demo Thread");
      System.out.println("Child thread: " + t);
      t.start(); // Start the thread
   }

   // This is the entry point for the second thread.
   public void run() {
      try {
         for(int i = 5; i > 0; i--) {
            System.out.println("Child Thread: " + i);
            // Let the thread sleep for a while.
            Thread.sleep(500);
         }
     } catch (InterruptedException e) {
         System.out.println("Child interrupted.");
     }
     System.out.println("Exiting child thread.");
   }
}

public class ThreadDemo {
   public static void main(String args[]) {
      new NewThread(); // create a new thread
      try {
         for(int i = 5; i > 0; i--) {
           System.out.println("Main Thread: " + i);
           Thread.sleep(1000);
         }
      } catch (InterruptedException e) {
         System.out.println("Main thread interrupted.");
      }
      System.out.println("Main thread exiting.");
   }
}
```

This would produce following result:

```
Child thread: Thread[Demo Thread,5,main]
Main Thread: 5
Child Thread: 5
Child Thread: 4
Main Thread: 4
Child Thread: 3
Child Thread: 2
Main Thread: 3
Child Thread: 1
Exiting child thread.
Main Thread: 2
Main Thread: 1
Main thread exiting.
```

Create Thread by Extending Thread:

The second way to create a thread is to create a new class that extends **Thread**, and then to create an instance of that class.

The extending class must override the **run( )** method, which is the entry point for the new thread. It must also call **start( )** to begin execution of the new thread.

Example:

Here is the preceding program rewritten to extend Thread:

```
// Create a second thread by extending Thread
```

```
class NewThread extends Thread {
   NewThread() {
      // Create a new, second thread
      super("Demo Thread");
      System.out.println("Child thread: " + this);
      start(); // Start the thread
   }

   // This is the entry point for the second thread.
   public void run() {
      try {
         for(int i = 5; i > 0; i--) {
            System.out.println("Child Thread: " + i);
   // Let the thread sleep for a while.
            Thread.sleep(500);
         }
      } catch (InterruptedException e) {
         System.out.println("Child interrupted.");
      }
      System.out.println("Exiting child thread.");
   }
}

public class ExtendThread {
   public static void main(String args[]) {
      new NewThread(); // create a new thread
      try {
         for(int i = 5; i > 0; i--) {
            System.out.println("Main Thread: " + i);
            Thread.sleep(1000);
         }
      } catch (InterruptedException e) {
         System.out.println("Main thread interrupted.");
      }
      System.out.println("Main thread exiting.");
   }
}
```

This would produce following result:

```
Child thread: Thread[Demo Thread,5,main]
Main Thread: 5
Child Thread: 5
Child Thread: 4
Main Thread: 4
Child Thread: 3
Child Thread: 2
Main Thread: 3
Child Thread: 1
Exiting child thread.
Main Thread: 2
Main Thread: 1
Main thread exiting.
```

Thread Methods:

Following is the list of important medthods available in the Thread class.

SN	Methods with Description
1	**public void start()** Starts the thread in a separate path of execution, then invokes the run() method on this Thread object.
2	**public void run()** If this Thread object was instantiated using a separate Runnable target, the run() method is invoked on that Runnable object.

3	**public final void setName(String name)** Changes the name of the Thread object. There is also a getName() method for retrieving the name.
4	**public final void setPriority(int priority)** Sets the priority of this Thread object. The possible values are between 1 and 10.
5	**public final void setDaemon(boolean on)** A parameter of true denotes this Thread as a daemon thread.
6	**public final void join(long millisec)** The current thread invokes this method on a second thread, causing the current thread to block until the second thread terminates or the specified number of milliseconds passes.
7	**public void interrupt()** Interrupts this thread, causing it to continue execution if it was blocked for any reason.
8	**public final boolean isAlive()** Returns true if the thread is alive, which is any time after the thread has been started but before it runs to completion.

The previous methods are invoked on a particular Thread object. The following methods in the Thread class are static. Invoking one of the static methods performs the operation on the currently running thread

SN	Methods with Description
1	**public static void yield()** Causes the currently running thread to yield to any other threads of the same priority that are waiting to be scheduled
2	**public static void sleep(long millisec)** Causes the currently running thread to block for at least the specified number of milliseconds
3	**public static boolean holdsLock(Object x)** Returns true if the current thread holds the lock on the given Object.
4	**public static Thread currentThread()** Returns a reference to the currently running thread, which is the thread that invokes this method.
5	**public static void dumpStack()** Prints the stack trace for the currently running thread, which is useful when debugging a multithreaded application.

Example:

The following ThreadClassDemo program demonstrates some of these methods of the Thread class:

```
// File Name : DisplayMessage.java
// Create a thread to implement Runnable
public class DisplayMessage implements Runnable
{
   private String message;
   public DisplayMessage(String message)
```

```
   {
      this.message = message;
   }
   public void run()
   {
      while(true)
      {
         System.out.println(message);
      }
   }
}

// File Name : GuessANumber.java
// Create a thread to extentd Thread
public class GuessANumber extends Thread
{
   private int number;
   public GuessANumber(int number)
   {
      this.number = number;
   }
   public void run()
   {
      int counter = 0;
      int guess = 0;
      do
      {
          guess = (int) (Math.random() * 100 + 1);
          System.out.println(this.getName()
                      + " guesses " + guess);
          counter++;
      }while(guess != number);
      System.out.println("** Correct! " + this.getName()
                      + " in " + counter + " guesses.**");
   }
}

// File Name : ThreadClassDemo.java
public class ThreadClassDemo
{
   public static void main(String [] args)
   {
      Runnable hello = new DisplayMessage("Hello");
      Thread thread1 = new Thread(hello);
      thread1.setDaemon(true);
      thread1.setName("hello");
      System.out.println("Starting hello thread...");
      thread1.start();

      Runnable bye = new DisplayMessage("Goodbye");
      Thread thread2 = new Thread(hello);
      thread2.setPriority(Thread.MIN_PRIORITY);
      thread2.setDaemon(true);
      System.out.println("Starting goodbye thread...");
      thread2.start();

      System.out.println("Starting thread3...");
      Thread thread3 = new GuessANumber(27);
      thread3.start();
      try
      {
         thread3.join();
      }catch(InterruptedException e)
      {
         System.out.println("Thread interrupted.");
      }
      System.out.println("Starting thread4...");
      Thread thread4 = new GuessANumber(75);

   thread4.start();
      System.out.println("main() is ending...");
   }
}
```

This would produce following result. You can try this example again and again and you would get different result every time.

```
Starting hello thread...
Starting goodbye thread...
Hello
Hello
Hello
Hello
Hello
Hello
Hello
Hello
Hello
Thread-2 guesses 27
Hello
** Correct! Thread-2 in 102 guesses.**
Hello
Starting thread4...
Hello
Hello
.........remaining result produced.
```

Major Thread Concepts:

While doing Multithreading programming, you would need to have following concepts very handy:

- Thread Synchronization
- Interthread Communication
- Thread Deadlock
- Thread Control: Suspend, Stop and Resume

Using Multithreading:

The key to utilizing multithreading support effectively is to think concurrently rather than serially. For example, when you have two subsystems within a program that can execute concurrently, make them individual threads.

With the careful use of multithreading, you can create very efficient programs. A word of caution is in order, however: If you create too many threads, you can actually degrade the performance of your program rather than enhance it.

Remember, some overhead is associated with context switching. If you create too many threads, more CPU time will be spent changing contexts than executing your program!